

Through connectivity in applied computer systems – ADMOS and MARWIN projects

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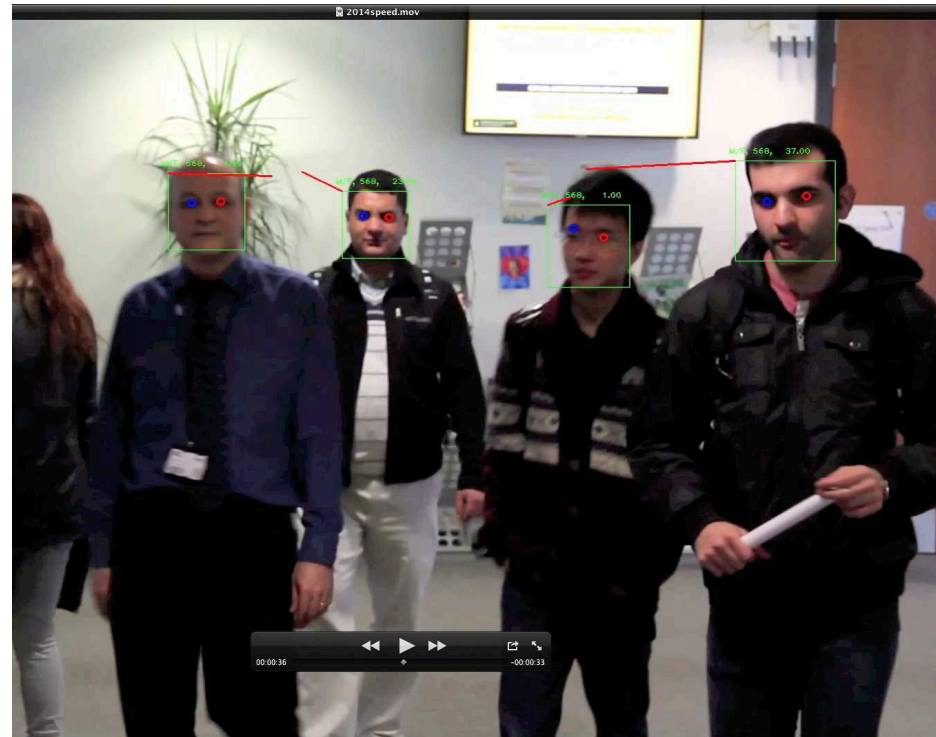
RODRIGUES, Marcos and KORMANN, Mariza (2015). Through connectivity in applied computer systems – ADMOS and MARWIN projects. In: 5th Annual International Scientific Conference on Education, Science, Innovations ESI 2015, Pernik, Bulgaria, June 10-11, 2015. (Unpublished)

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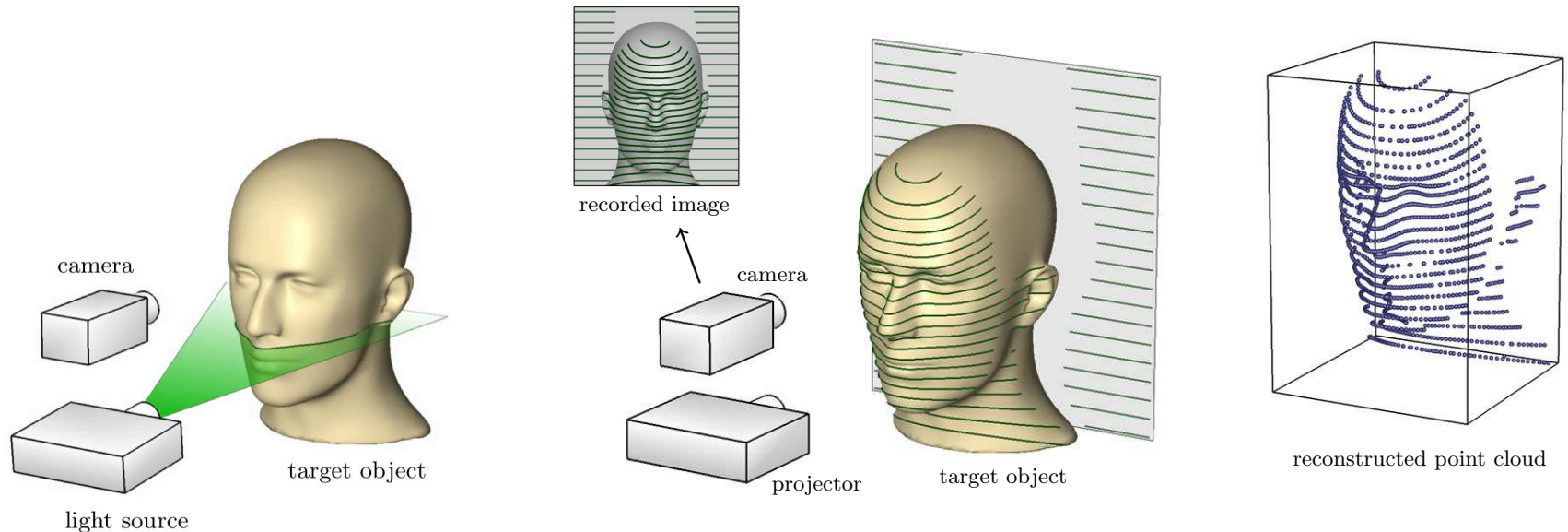
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Through Connectivity in Applied Computer Systems – ADMOS and MARWIN Projects

Marcos Rodrigues



The GMPR 3D scanning technologies *3D with single image*

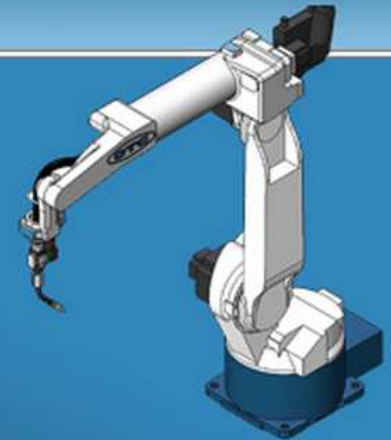


Each light plane is uniquely
detected by original algorithms

The MARWIN Project

FP7 Research for the Benefit of SMEs

A cognitive computer vision based welding robot



Grant Agreement No. 286284, 2011--2014

Project Coordinator:



Project Members:



MARWIN: SHU work on various tasks

Marcos Rodrigues, Mariza Kormann

3D Scanner Development

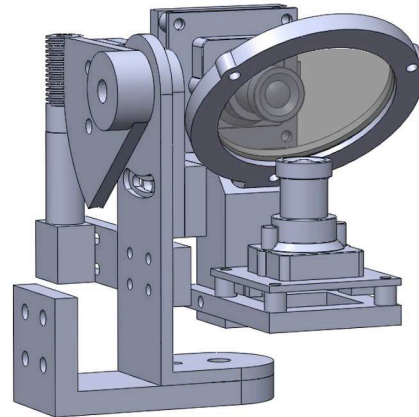
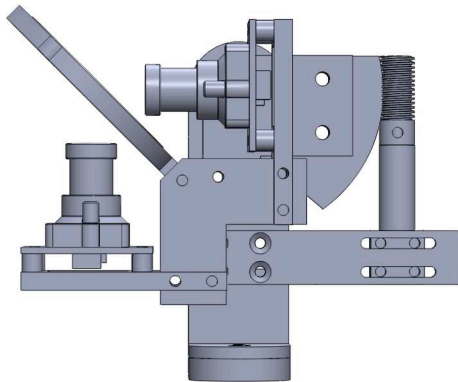
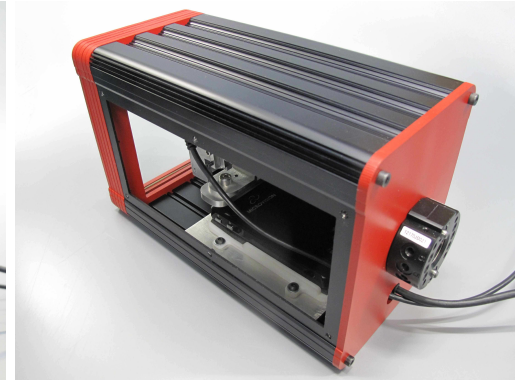
Registration and fusion of 3D models

Translating 3D welding sequence from CAD to scanned model

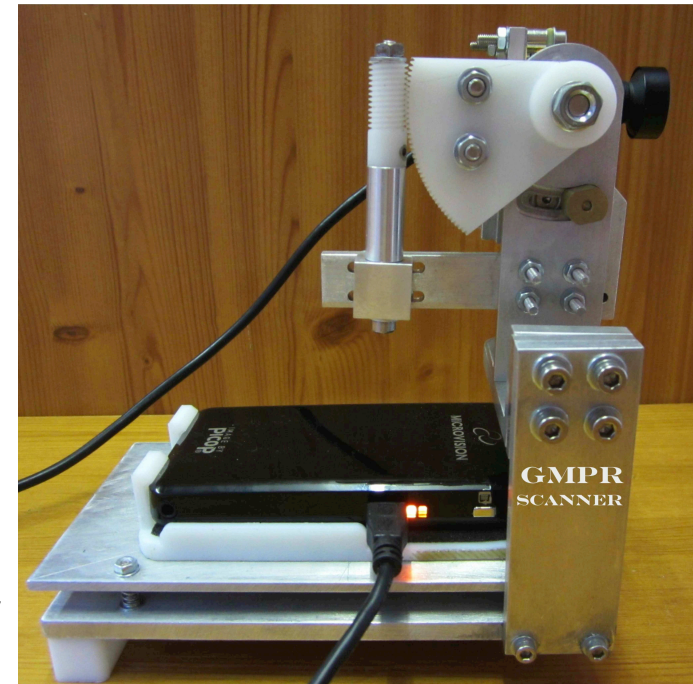
Dissemination

GMPR scanner design

A beam splitter allows for visible and near-infrared cameras to be fitted



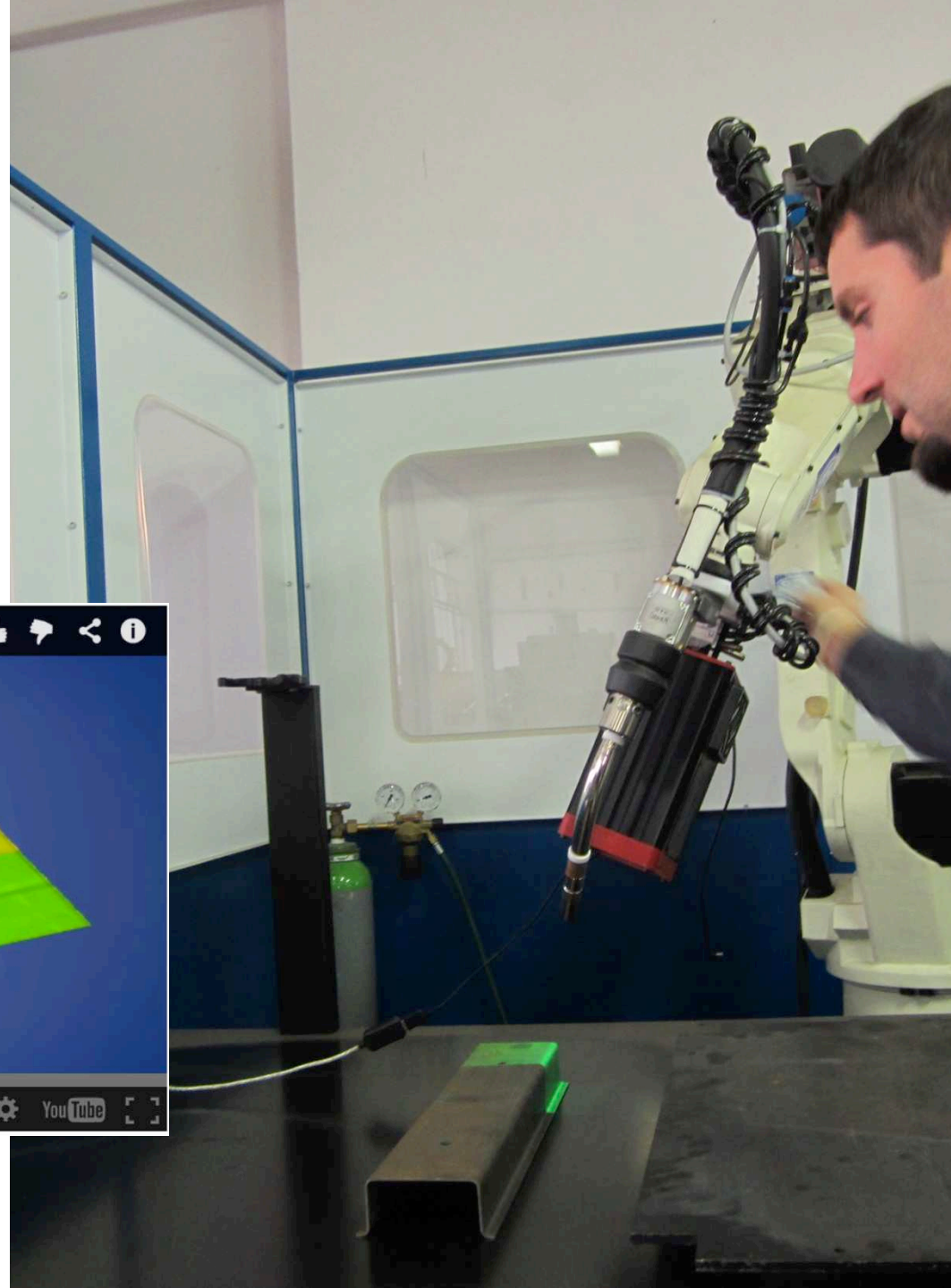
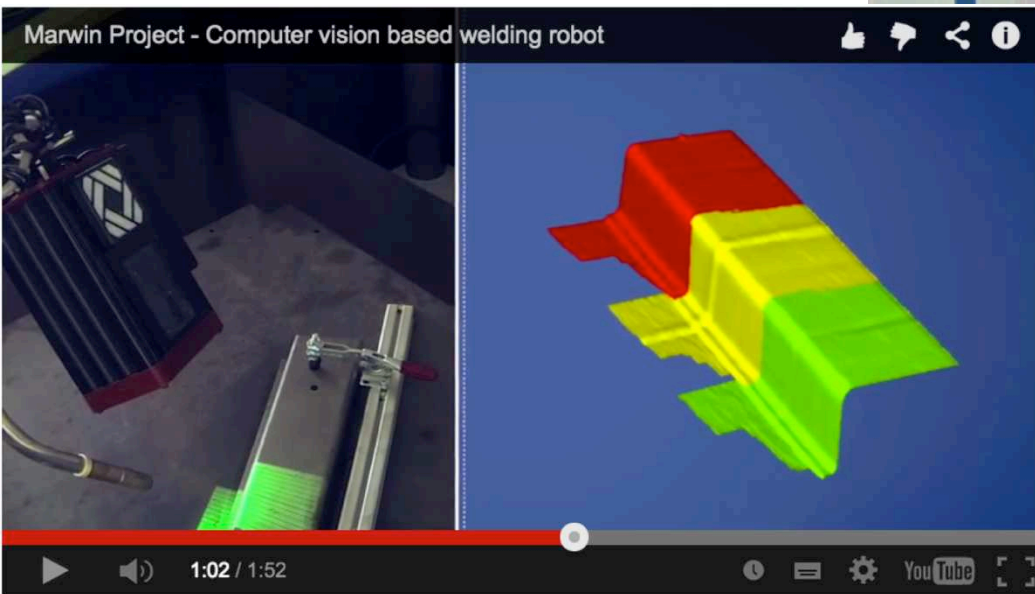
The prototype shown uses a MicroVision PicoP laser projector and an IDS CMOS camera (1280x1024)



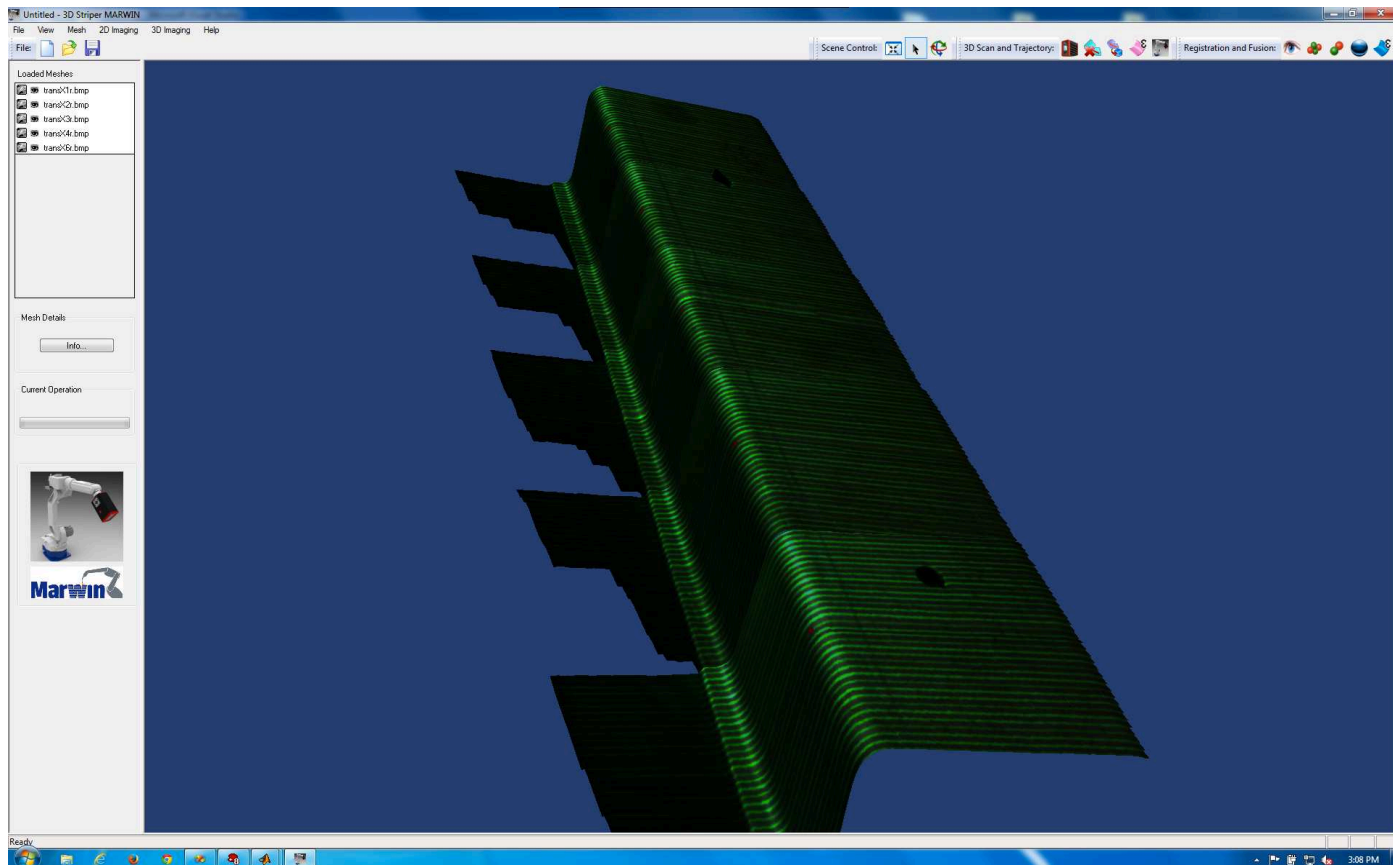
Full design integrated into a
robotic arm
The actual robotic cell



Scanning a part

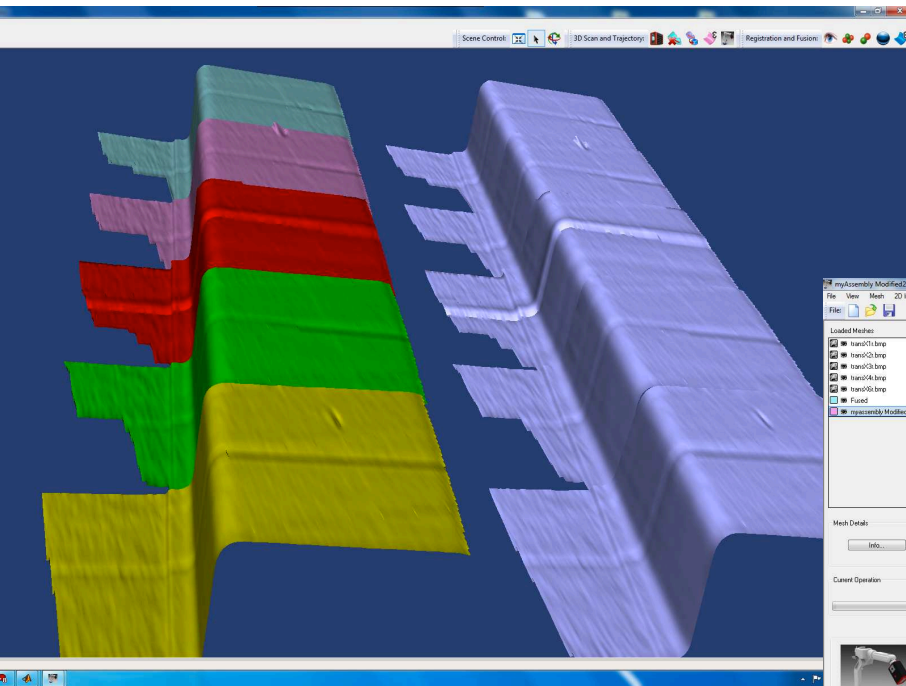


Scanning a part with the robot *As the robot moves the part is assembled*



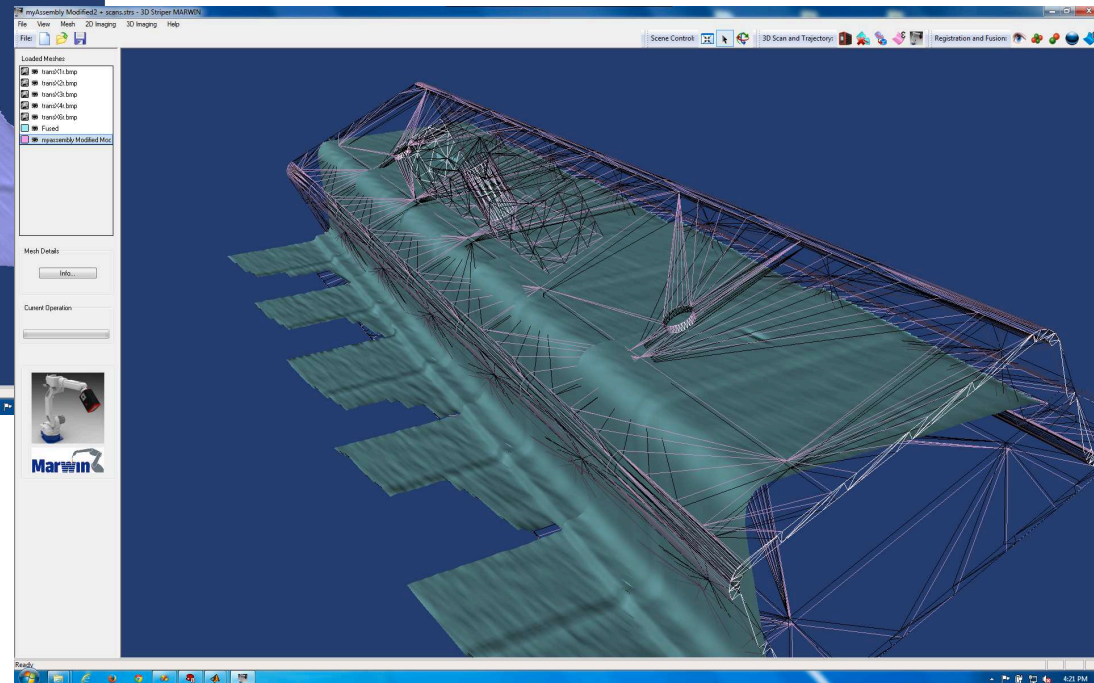
Automatic registration with CAD models

Scanned patches are fused and registered



Registration goal is to estimate \mathbf{R}, \mathbf{t} :

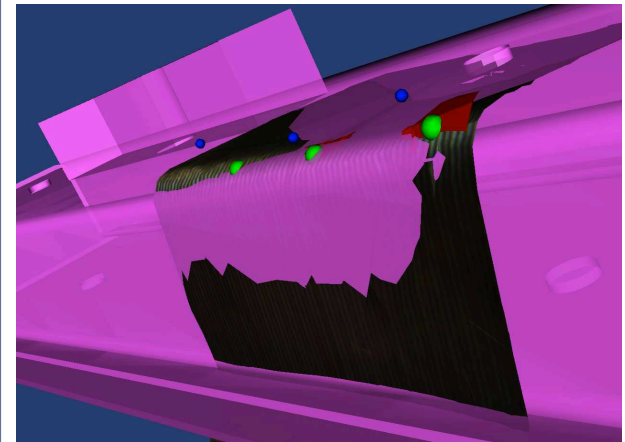
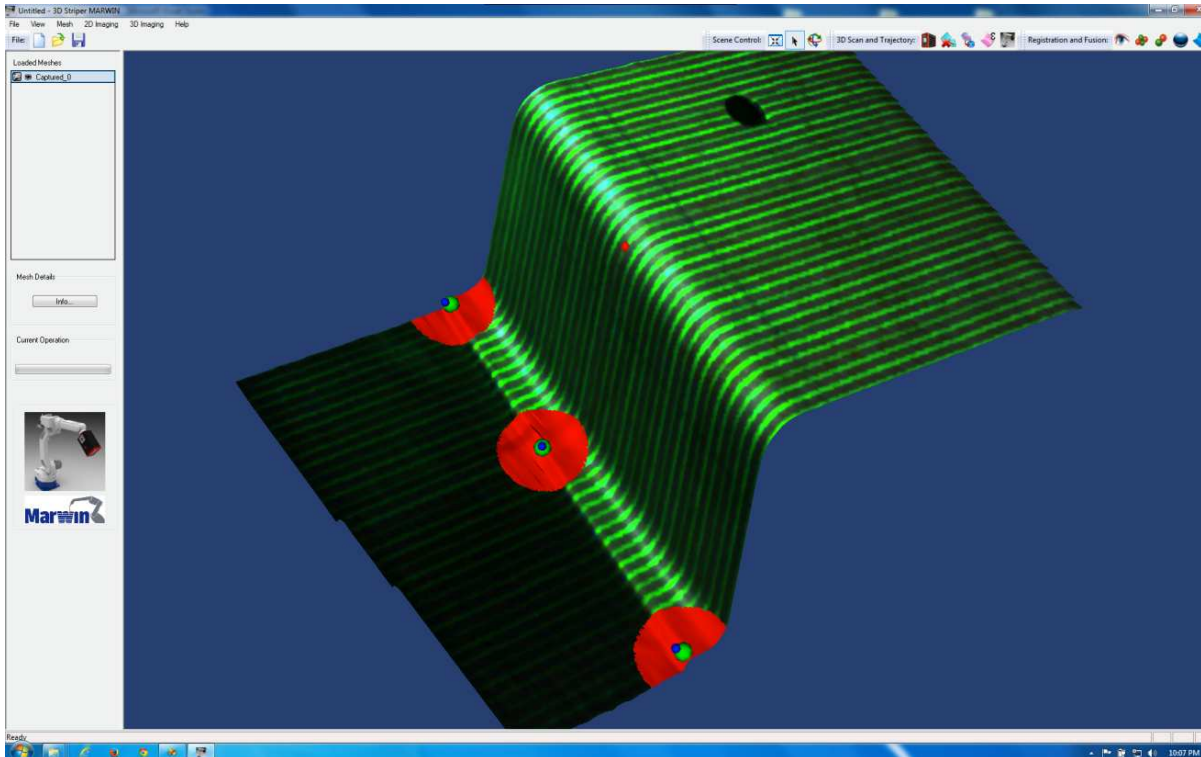
$$F(\mathbf{R}, \mathbf{t}) = \sum_{i=1}^m \sum_{j=1}^{N_i} p_{i,j} d^2(\mathbf{R}p_{i,j} + \mathbf{t}, S_k) + \sum_{k=1}^n \sum_{l=1}^{N_k} q_{k,l} d^2(\mathbf{R}^T p'_{k,l} - \mathbf{R}^T \mathbf{t}, S_i)$$



Least squares minimisation:

$$f(\mathbf{R}, \mathbf{t}) = \frac{1}{N} \sum_{i=1}^N \|\mathbf{R}\mathbf{p}_i + \mathbf{t}, \mathbf{q}_i\|^2$$

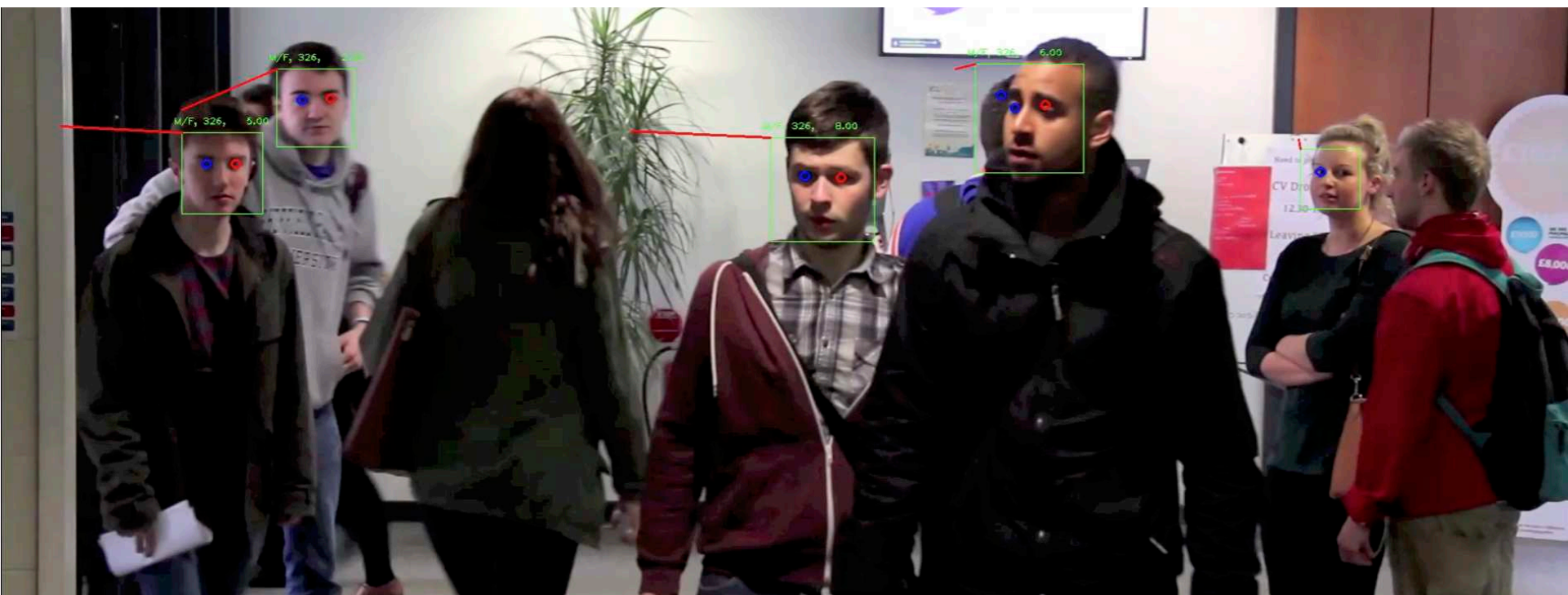
Welding sequence *Translated from CAD to scanned models*





The ADMOS Project

Gender classification and age estimation



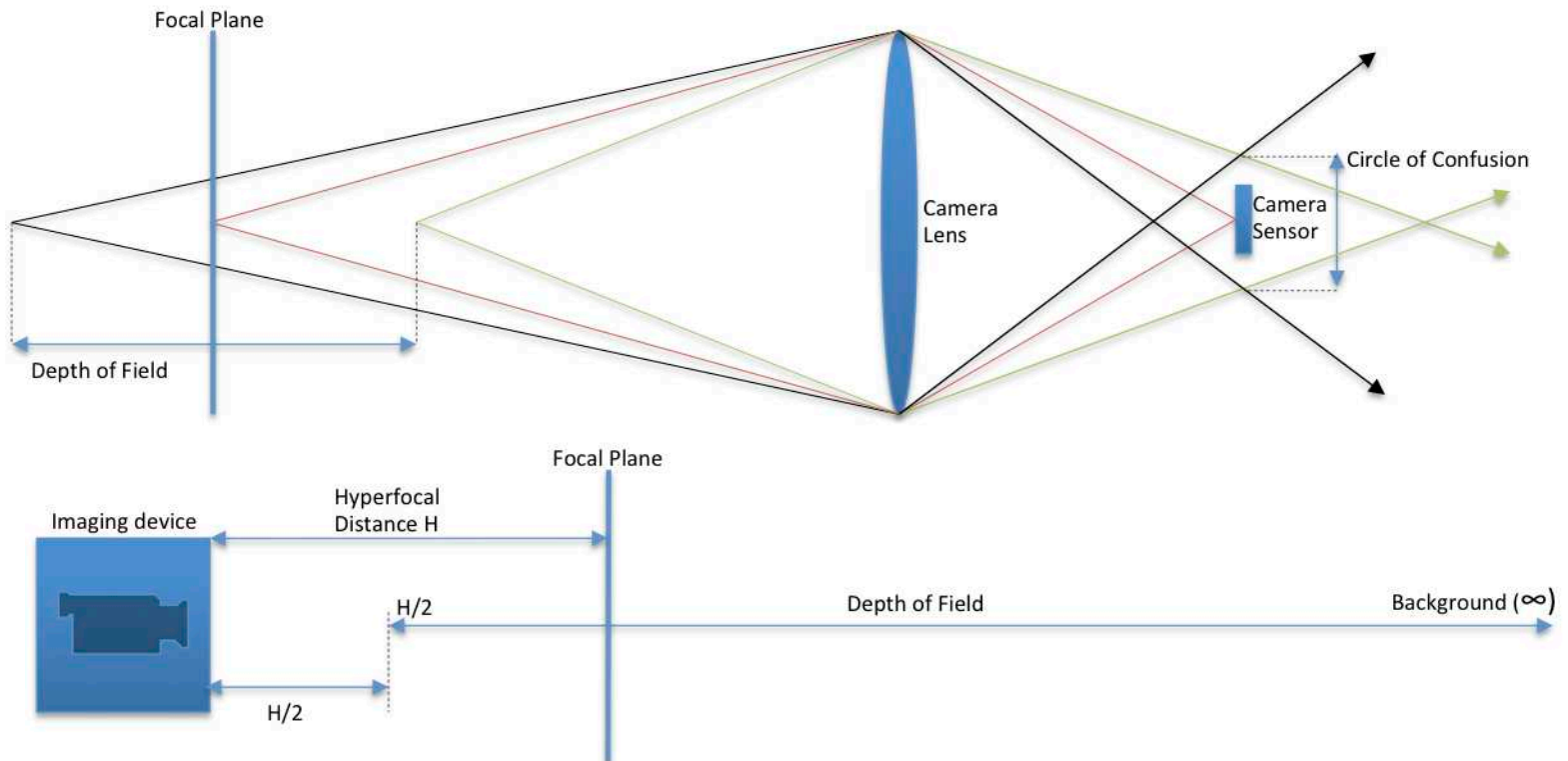
| ADMOS: SHU work on various tasks *Marcos Rodrigues, Mariza Kormann*

Privacy Regulations
Modelling and System Design
Hardware and Electronics Design
Client Side Software Development: tracking, gender
and age estimation
Dissemination

Hardware and Electronics Design

Optics and lighting

Optical lens and filters to ensure performance within various illuminating conditions

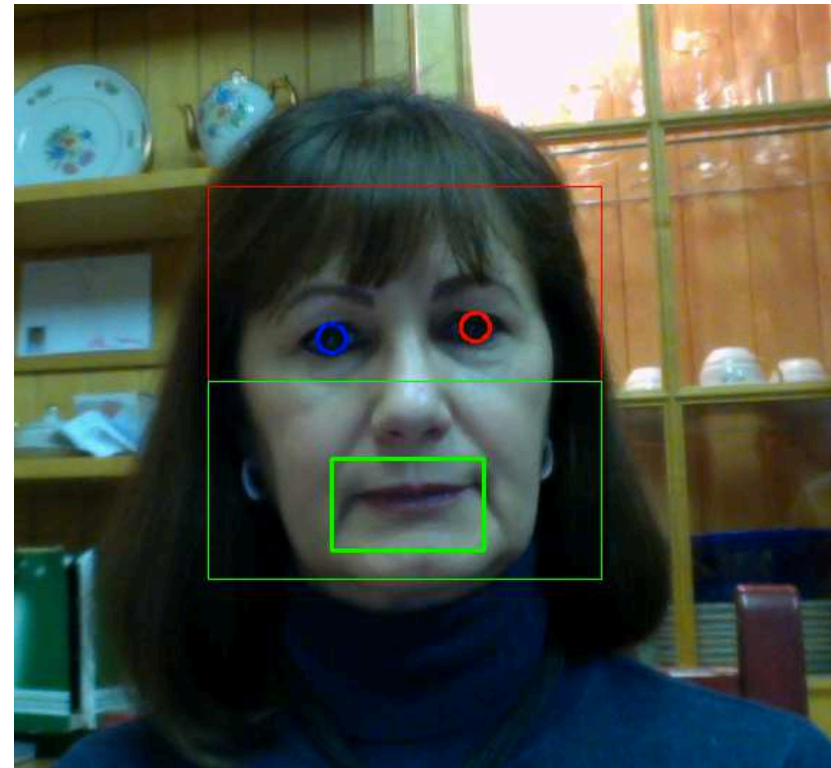


Client Side Software Development

Firmware and control s/w development

Real time processing:

1. *face detection and tracking*
2. *eye tracking*
3. *other feature tracking (mouth, nose)*
4. *cropping the various face-ROI*
5. *gender classification*
6. *age estimation*
7. *save statistical info to an xml file*
8. *transmit to server at periodic intervals*

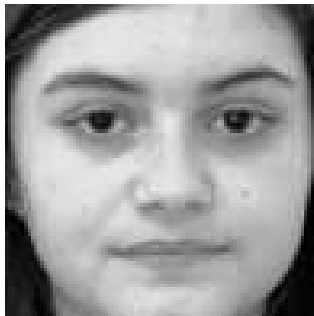


Binary patterns *LBP, CT and MCT*

Transformation	Decision function
$\text{LBP}_{P,R} = \sum_{p=0}^{P-1} T(I_p - I_c) 2^p$	$T(.) = \begin{cases} 1 & \text{if } (I_p - I_c) \geq 0, \\ 0 & \text{otherwise.} \end{cases}$
$CT_{m,n}(x, y) = \left\ \left\ _{i=-n/2}^{n/2} \left\ _{j=-m/2}^{m/2} f(I(x, y), I(x+i, y+j)) \right\ \right\ $	$f(u, v) = \begin{cases} 0 & \text{if } u \leq v, \\ 1 & \text{otherwise.} \end{cases}$

MCT is similar to CT, except that it uses the average intensity of the kernel window as the intensity of the centre pixel.

Applying binary patterns to face images *Visualizing the differences on images*



Input image



LBP 3x3



Census 3x3



Modified
Census 3x3



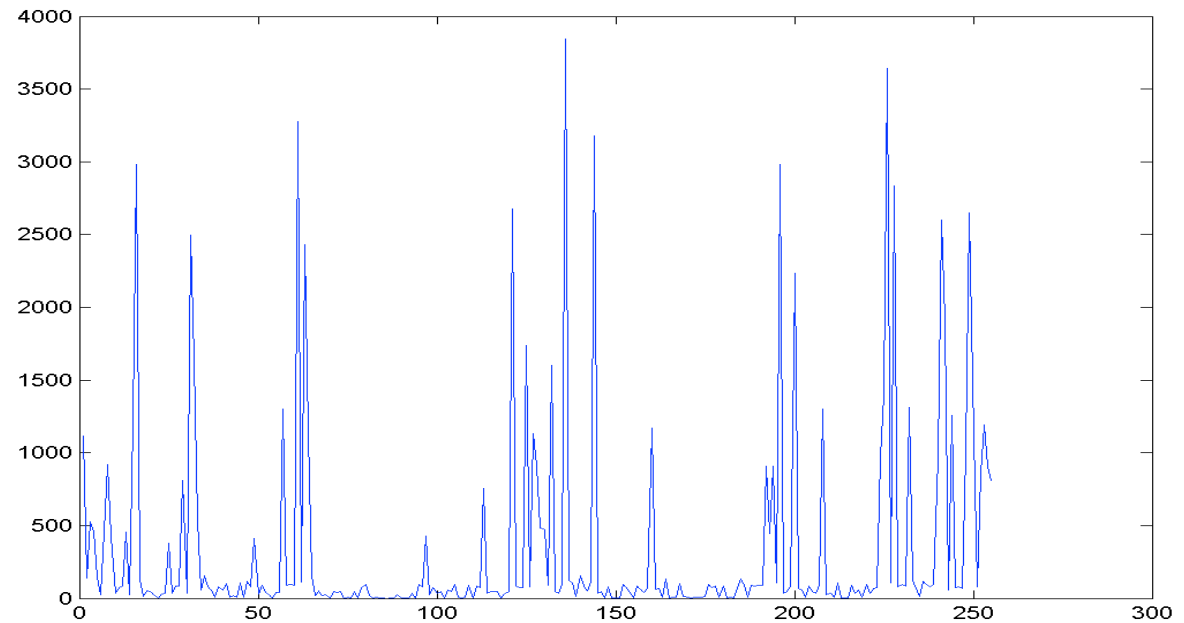
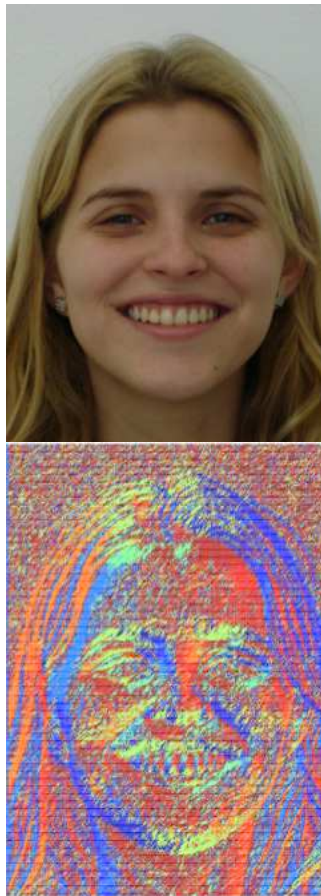
Census 5x5



Modified
Census 5x5

LBP processing

Features are defined by the histogram







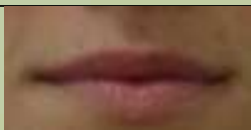
ROI sensitivity analysis

Male subjects tend to be classified with higher accuracy.

This agrees with all results reported in the literature.

No explanation for this behaviour is offered at this stage.

TABLE I
COMPARATIVE ANALYSIS OF IMAGE REGIONS

Image ROI	Gender	Classification results
		
ROI1	Male Female	92% 79%
		
ROI2	Male Female	83% 83%
		
ROI3	Male Female	88% 88%
		
ROI4	Male Female	88% 71%
		
ROI5	Male Female	<40% <40%

Comparative analysis of binary patterns

DCT-Discrete Cosine Transform

Decomposes a signal and defines it as a sum of cosines at different frequencies

$$y(k) = w(k) \sum_{n=1}^N z(n) \cos\left(\frac{\pi(2n-1)(k-1)}{2N}\right)$$

$$k = 1, 2, \dots, N$$

$$w(k) = \begin{cases} 1/\sqrt{N} & \text{for } k = 1, \\ \sqrt{2/N} & \text{for } 2 \leq k \leq N. \end{cases}$$

The length of coefficients y is the same size as the original signal z .

Comparative analysis of binary patterns

DWT-Discrete Wavelet Transform

$$x(n) h(n) = \sum_{k=-\infty}^{\infty} x(k) h(n - k)$$

$$y(n) = \sum_{k=-\infty}^{\infty} h(k) x(2n - k)$$

$$y_{\text{high}} = \sum_n x(n) g(2k - n)$$

$$y_{\text{low}} = \sum_n x(n) h(2k - n)$$

$$x(n) = \sum_{k=-\infty}^{\infty} (y_{\text{high}}(k) \cdot g(-n + 2k)) (y_{\text{low}}(k) \cdot h(-n + 2k))$$

Comparative analysis of binary patterns

Raw histograms

Transformed histograms by DCT

Transformed histograms by DWT



Original



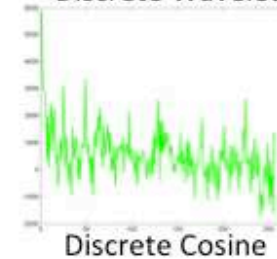
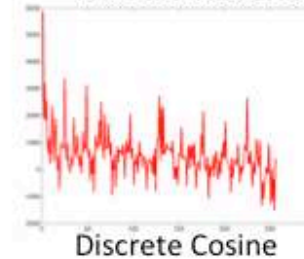
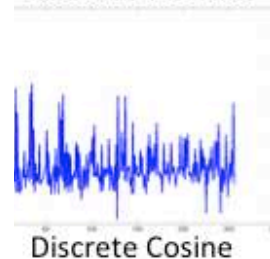
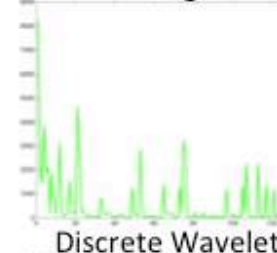
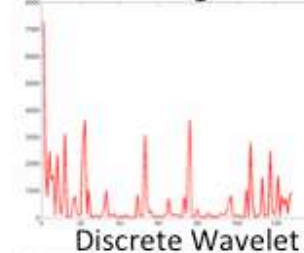
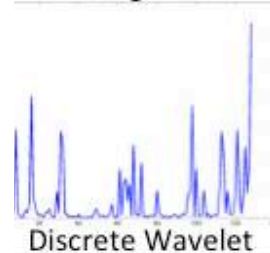
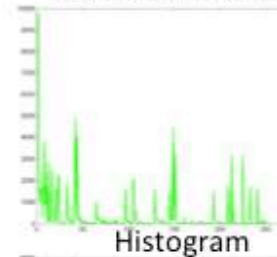
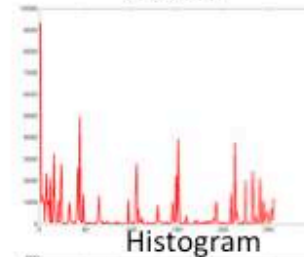
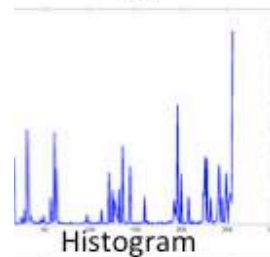
LBP



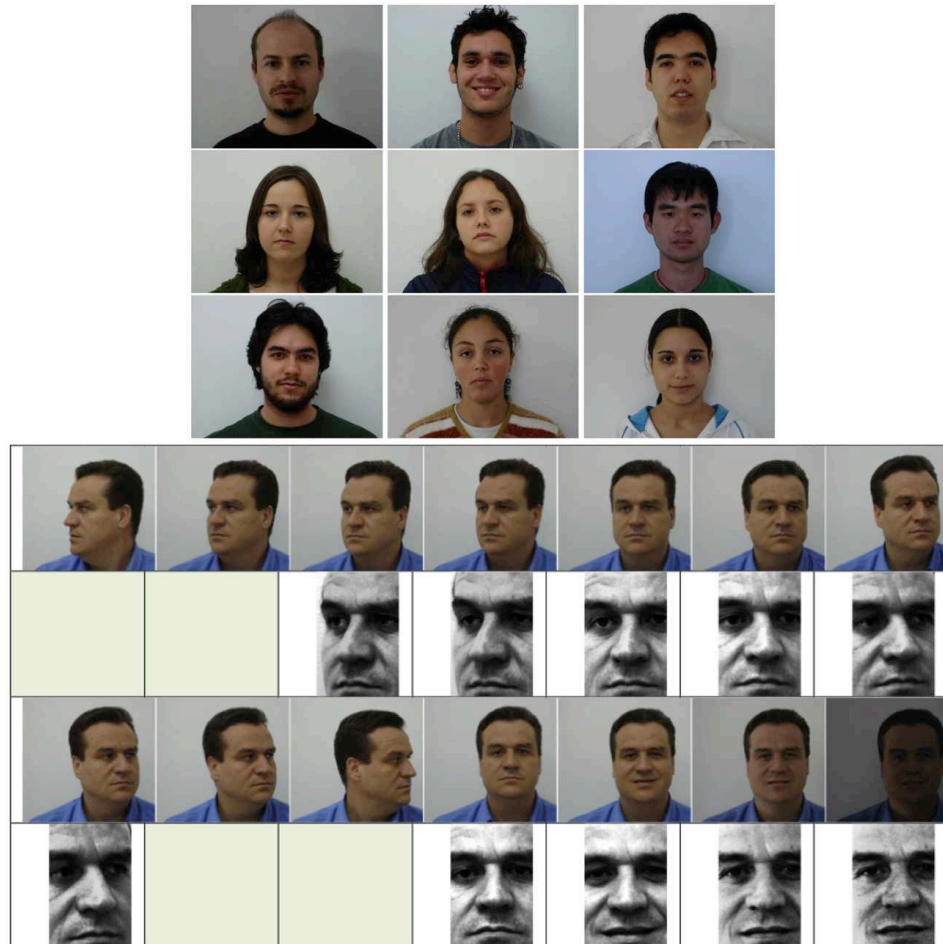
Census



Modified Census



Tested on public databases
FEI, AT&T, Sheffield-UMIST, and color FERET



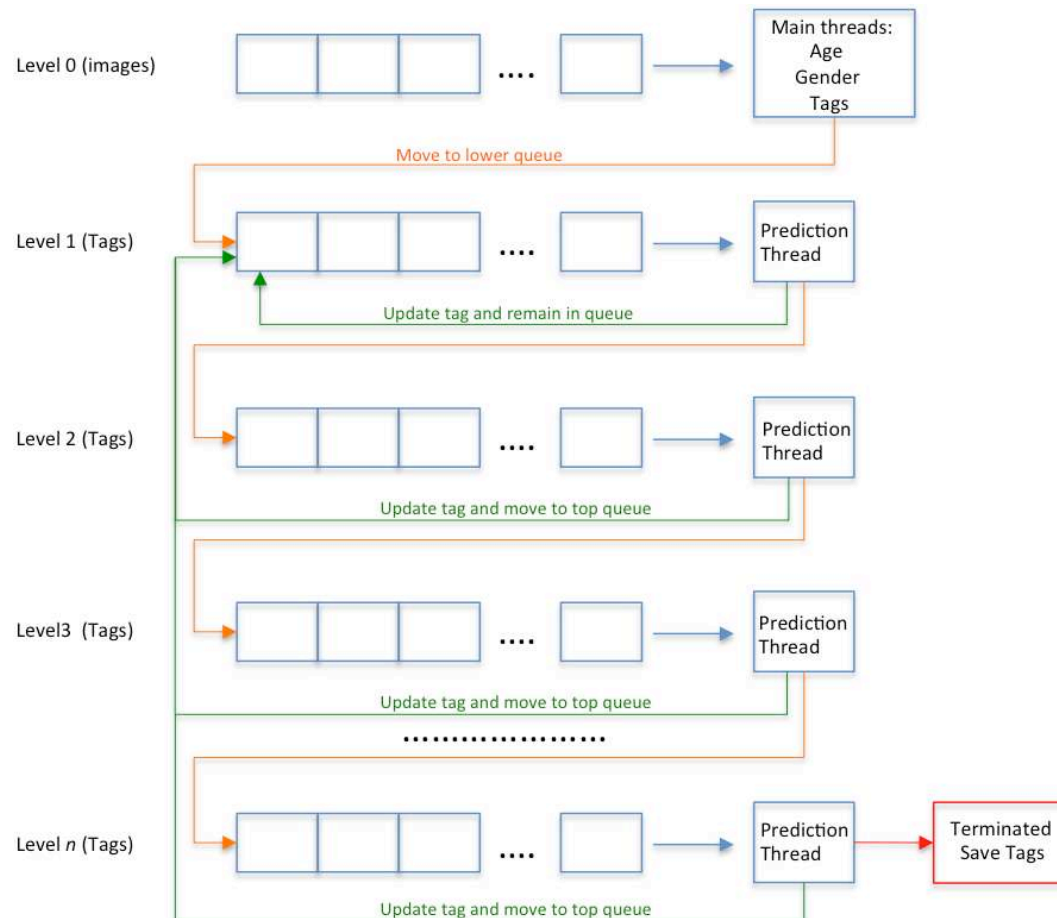
Classification results

Average for 4 Regions of Interest

	LBP	CT	MCT	LBP CT	LBP MCT
FEI Database					
LBP&Census	87.9	87.6	79.0	86.3	85.2
DWT	85.2	84.4	79.0	86.3	84.1
DCT	86.8	89.8	81.2	87.4	85.7
AT&T					
LBP&Census	66.4	65.3	50.0	77.9	50.0
DWT	59.1	50.0	50.0	69.6	50.0
DCT	84.2	87.0	90.1	83.2	80.3
Sheffield-UMIST					
LBP&Census	81.6	82.8	67.8	78.7	68.4
DWT	77.2	78.0	73.2	75.8	83.6
DCT	84.6	84.3	83.0	86.5	85.2
Color FERET					
LBP&Census	69.5	68.1	70.3	67.9	70.6
DWT	71.5	72.0	67.1	72.4	69.6
DCT	71.9	68.8	70.9	73.1	73.6

Real time and privacy requirements

Define and track anonymous tags



Conclusions

LBP + Eigenvector decomposition: top half of the face most significant

Binary patterns + SVM: LBP is slightly superior to CT/MCT

Binary patterns + DCT + SVM: CT is clearly the superior technique

Also, bias towards male subjects is removed

CT has the smallest standard deviation of all techniques

Real-time performance: enabled by multiple threads using multi-level queues

Testing in shopping malls in Hungary and UK in June and July 2015

